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# A methodology to determine size and shape of plots for sugarcane plantation

Adriana Cristina Cherri[1], Andrea Carla Gonçalves Vianna[2], Rômulo Pimentel Ramos[3], Helenice de Oliveira Florentino[4]*

[1]Universidade Estadual Paulista/FC – Depto. de Matemática, Av. Eng. Luiz Edmundo Carrijo Coube, 14-01 – 17033-360 – Bauru, SP – Brasil.
[2]Universidade Estadual Paulista/FC – Depto. de Computação.
[3]Universidade Estadual Paulista/FCA – Depto. de Energia na Agricultura, R. José Barbosa de Barros, 1780 – 18610-307 – Botucatu, SP – Brasil.
[4]Universidade Estadual Paulista/IB – Depto. de Bioestatística, R. Prof. Dr. Antônio Celso Wagner Zanin, 250 – 18618-689 – Botucatu, SP – Brasil.
*Corresponding author <helenice.silva@unesp.br>

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**ABSTRACT**: Brazil is the largest sugarcane producer in the world and the leader in the production of sugar and ethanol. Although sugarcane has become an important factor in the Brazilian economy, cultivation has presented many issues, for example, the problems due to burning before the manual harvest. The Brazilian authorities have approved a law that prohibits this practice and mechanized harvesting has thus become the most fitting approach. Given this development, areas for sugarcane plantation must be properly rebuilt to accommodate the new way of harvesting. The main characteristic demanded of sugarcane plots to use harvesting machines is that they must be rectangular. In the present paper, we propose a methodology for dividing the plantation area into plots and planning their allocation so as to accommodate mechanized harvesting. In view of the requirement for plots to be rectangular, we represented this problem as a two-dimensional cutting problem, and to find a solution we adopted the AND/OR graph approach. The computational experiments were conducted using real cases, and the proposed strategy was shown to perform well.

**Keywords**: planting planning, sugarcane culture, mechanized harvesting, AND/OR graph approach

## Introduction

Due to the growth in the consumption of ethanol and sugar, the sugarcane production process has undergone important changes, mainly in terms of harvesting methods. The manual harvesting systems once used have been replaced by mechanized procedures. This change is attributable to several factors such as the reduction in harvesting cost, the decreasing supply of skilled labor and, principally, the Agro Environmental Protocol proposed by the sugarcane industry association UNICA (União da Indústria de Cana-de-Açúcar) and the government of the state of São Paulo. This protocol established the complete elimination of the practice of sugarcane burning in 2017 (Cervi et al., 2015).

Solano et al. (2017) identified the main technical factors that affect the implementation of mechanized harvesting systems. The authors identified important technical constraints in the system of planting, particularly the size and shape of the plots, the appropriate row spacing and the selection of sugarcane varieties suitable for mechanical harvesting. For efficient use of mechanized harvesting it is necessary to adopt larger and more uniform plots.

According to Florentino et al. (2015), for maximum efficiency of the harvesting machine and minimal cost, it is necessary to plan the plot design and sugarcane rows in such a way as to necessitate the fewest possible maneuvers. The plots should have a rectangular form at least 600 m long, well-leveled ground, parallelism between rows and adequate spacing to obtain maximum efficiency (Paixão et al., 2016). Benedini and Conde (2008) affirm that the plots should have a furrow length of 500-800 m and a width of 150-400 m and the spacing between rows should be 1.5 m. Bharati et al. (2017) recommend that most plots be rectangular with the greatest possible length for more efficient use of the harvesting machines. The sugarcane rows must be strategically placed to avoid excessive maneuvers and, consequently, lost time. According to Rossatto et al. (2015), the plots are generally subdivided based on topography and soil homogeneity and should present an average area of between 10 and 20 hectares.

In this study we proposed a methodology to aid the division of the sugarcane planting areas in rectangular plots, so as to minimize the number of harvesting machine maneuvers. This methodology uses a two-dimensional cutting stock problem approach. Two-dimensional cutting stock problems have been intensively researched due to their importance in several industrial processes (Gilmore and Gomory, 1965; Hertz, 1972; Neidlein et al., 2008, Kim et al., 2014; Malaguti et al., 2014). Due to the difficulty in solving these problems, there are a large number of heuristic procedures proposed in the literature to solve them (Morabito et al., 1992; Lodi et al., 2002; Wei et al., 2017). Among these strategies, we chose the AND/OR graph approach, developed by Morabito et al. (1992), due to the flexibility and efficiency of this technique to solve problems in two dimensions.

## Materials and Methods

Brazil expands annually approximately 5 % of the sugarcane planting area and about 18 % of the cane fields are replanted. Consequently, there is a large area that needs to be divided into plots or the current plots need to be rebuilt, for the sugarcane that is planted to meet the recommendations for mechanized harvesting. Thus, the present paper proposes a methodology for planning the division of the planting area into plots that address such characteristics and their allocation.